

A Method of Calculating the Orbit of a Planet or Comet from Three observed Places. By Professor Challis.

This method resembles in principle that of Laplace, of which it may be regarded an extension, the object of the author being to include in the calculation differential coefficients of the *third* and *fourth* orders, for the purpose of insuring greater accuracy in the final results. The equations by which the problem is solved are formed as follows. If α and β be the observed right ascension and north polar distance of the body at one of the given times, corrected to a given equinox and given position of the earth's equator, and x, y, z be its co-ordinates at the same time, having their origin at the place of the observer, these quantities are related to each other by the two equations

$$x = y \cot \alpha, \quad x = z \cos \alpha \tan \beta.$$

Each observed place furnishes two such equations. To include parallax the origin of co-ordinates is transferred to the earth's centre. If ξ be the distance of the body from the earth, and q be the aberration constant, the effect of aberration is taken into account by changing x, y, z respectively into $x - \frac{dx}{dt} q \xi, y - \frac{dy}{dt} q \xi, z - \frac{dz}{dt} q \xi$. The origin of co-ordinates is then transferred to the centre of the sun, by calculating exactly the sun's co-ordinates at the three times of observation. Thus six equations are formed in which the unknown quantities are the heliocentric co-ordinates of the body. The co-ordinates at the first and last times of observation are expressed in terms of the co-ordinates at the intermediate time, by series including differential co-efficients of the *fourth* order of the latter co-ordinates. The six unknown quantities to be found are then, the heliocentric co-ordinates x_2, y_2, z_2 at the middle time, and their first differential co-efficients $\frac{dx_2}{dt}, \frac{dy_2}{dt}, \frac{dz_2}{dt}$. A first solution is obtained by including only differential co-efficients of the second order, and neglecting the aberration terms. This conducts to the following values of the co-ordinates,—

$$x_2 = M + \frac{N}{r_2^3}, \quad y_2 = M' + \frac{N'}{r_2^3}, \quad z_2 = M'' + \frac{N''}{r_2^3},$$

r_2 being the body's heliocentric distance. Hence

$$r_2^2 = \left(M + \frac{N}{r_2^3}\right)^2 + \left(M' + \frac{N'}{r_2^3}\right)^2 + \left(M'' + \frac{N''}{r_2^3}\right)^2.$$

For solving this equation, a graphical method given by I. I. Waterston, Esq. in the *Monthly Notice* of the Royal Astronomical Society for December 1845, is recommended. The value of r_2 being

found, those of x_2, y_2, z_2 , and their first differential co-efficients, are readily derived, the equations for determining them being linear.

By means of the first approximate values of the unknown quantities, the second order of approximation is proceeded with so as to include differential co-efficients of the third order and the more important aberration terms. The third approximation includes differential co-efficients of the fourth order, and some small additional aberration terms. These approximations are so conducted that the quantities obtained are *corrections* to the first obtained values, and it is consequently not necessary to calculate with seven-figure logarithms.

The values of $x_2, y_2, z_2, \frac{dx_2}{dt}, \frac{dy_2}{dt}, \frac{dz_2}{dt}$, being thus obtained as accurately as possible, the elements of the orbit are readily derived by known formulæ. As the observed right ascension and north polar distance were not corrected into latitudes and longitudes, the elements are by this calculation referred to a plane through the sun's centre parallel to the earth's equator in a given position. By a simple computation they may be transferred to the plane of the ecliptic. But the original form is the most convenient for obtaining geocentric co-ordinates in terms of the eccentric anomaly, for the purpose of calculating an ephemeris; and also for deriving equations of condition by which the elements may be corrected by future observations. The method of doing this the author proposes to describe at another opportunity.

A brief Notice of the Imperial Observatory of Poulkova.

By the Astronomer Royal.*

The Observatory of Poulkova was built on the plans furnished by its director, M. Struve; the instruments are, for the most part, constructed according to his special instructions. The peculiar scope of this noble establishment is *sidereal* astronomy in its widest sense; and Mr. Airy strongly expresses his admiration of the definiteness of the purpose which M. Struve had in his mind, and of the thorough manner in which it has been carried into effect. He says that "no astronomer can feel himself perfectly acquainted with modern astronomy in its most highly cultivated form, whether as regards the personal establishment, the preparation of the buildings, the selection or construction of the instruments, or the delicacy of using them, who has not well studied the Observatory of Poulkova. To this excellence many antecedent circumstances have

* The Astronomer Royal visited Poulkova last summer, and gave orally an account of the Observatory at the meeting of the Society in November, the substance of which was communicated in a letter to Professor Schumacher, and printed in the *Astronomische Nachrichten*.